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EXPERIMENTS WITH DROSOPHILA MELANOGASTER IN MAGNETIC FIELDS

By

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Research Report

EXPERIMENTS WITH DROSOPHILA MELANOGASTER IN MAGNETIC FIELDS*

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SUMMARY PAGE

THE PROBLEM

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The present study is an attempt to resolve the contradictory findings which have resulted from previous experimental investigations on the effects of magnetic fields on biological systems. Because of the short period of generation in Drosophila and the wealth of genetic information obtainable, this species is a promising one for magnetic investigation.

FINDINGS

No genetic effects of homogeneous magnetic fields up to a field strength of 120,000 gauss and an exposure time of one hour were observed on Drosophila; neither do such effects seem to exist in strong inhomogeneous fields with high gradients of field strength. In most of the experiments the biological systems were exposed during the total development time from egg to imago. Synergetic effects on Drosophila of the magnetic field in combination with x-radiation, starvation, hyperoxia, and hypoxia have also not been observed.

AUTHOR

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INTRODUCTION

The effects of magnetic fields on Drosophila have often been investigated (1-4). The short period of generations and the wealth of genetic information accumulated on this species have prompted the interest in Drosophila for studies of magnetic effects. The results often have been contradictory with no effects observed in some cases as opposed to lethal effects reported in other investigations under apparently similar experimental conditions.

The selection of the following experiments was influenced by a desire to apply the magnetic field in a manner not previously used as well as by the intention to reproduce preceding work: 1) Extremely high intensity magnetic fields were employed; 2) the fields were applied during the total life cycle of the animals, and 3) synergetic effects were studied with the magnetic field applied in addition to other stress factors such as x-radiation, hypoxia, and starvation. This variety in the experimental approach appeared timely when little was known about the actual sites and the mechanism of biomagnetic effects.

SURVIVAL AND GENETICS OF DROSOPHILA IN VERY HIGH INTENSITY MAGNETIC FIELDS

Experiments on the survival of Drosophila in magnetic fields with a field strength of 120,000 gauss maximal have been described and discussed in a previous report (1). These fields were available in a modified Bitter magnet at the Naval Research Laboratory, Washington, D. C. The results of this study are summarized by stating that the flies survived exposure to homogeneous fields up to 120,000 gauss. Inhomogeneous fields with high field gradient had lethal effects. At field strengths from 40,000 to 100,000 gauss with a gradient of more than 6,000 gauss/cm flies died regularly after exposure for more than one-half hour.

In connection with these survival studies some genetic observations were made, using the following approaches:

1). The "Muller 5" strain of D. melanogaster contains a recessive "yellow body" gene on the X-chromosome. The trait is observed in females receiving a Wild-type homolog from the male parent. It becomes manifest in the F-1 females in the event of mutation at this locus in the exposed male parent.

Male Wild-type Drosophila were placed for thirty minutes in a homogeneous field of 100,000 gauss. Three days later the male flies were crossed with virgin Muller-5 females. Only one yellow body female was observed out of 250 female F-1 flies with normal body color, while no mutants were observed among 218 female F-1 controls. As the number of animals observed was small these results are not conclusive so far as deviation from normal recessive mutation rate at this locus is concerned. It should be pointed out, however, that all the F-1 flies examined, with the one noted exception, appeared normal and were fertile.

sample contained ten eggs of the Wild-type strain in a pillbox-like container (1-inch radius, 1/2 inch high), half filled with medium. A total of 100 eggs were exposed in 10 batches during the total time of development from egg to newly hatched fly.

Results

Since no significant effect of the field strength was observed, the results of all samples are lumped. While 81 (38 male, 43 female) imagoes formed in the field, 74 (37 male, 37 female) were counted in the control samples. The homogeneous magnetic field has obviously no effect on the hatch counts or on the determination of the sex of the developing flies.

EXPERIMENTS IN INHOMOGENEOUS FIELDS

Procedure

The inhomogeneous field was generated by using different size pole pieces on the electromagnet. The field, measured at the place of the center of the sample, was 11,000 gauss with a gradient of 1500 gauss/cm. The size of the sample container, number of eggs per batch, and temperature regulation were the same as in the previous experiment. In addition, the hatch count of eggs from flies which had previously been raised in the magnetic field was determined and compared with controls.

Results

Tables I and II show that the duration of the life cycle of Drosophila and the percentage of hatch were not significantly influenced by the inhomogeneous magnetic field.

In addition, the percentage hatch of animals whose parents had been exposed during their complete development cycle to a magnetic field was not significantly different from controls whose ancestors had at no time been exposed to a magnetic field of greater intensity than the geomagnetic field. This shows that, in the first generation, no lethal inheritable changes were induced.

In some experiments pupae only were exposed to the field. Pupae of Wild-type Drosophila within one day of formation were placed in a field of 15,000 gauss field strength and a gradient of 3500 gauss/cm and left in the field till the flies developed. Each pupa was placed inside a separate polyethylene capillary tube of 1.5 mm inside diameter, and plugged on both sides with cotton. The tubes were glued to the pole pieces at places where high field gradients were measured. No difference in hatch time was noted between the exposed group and controls.

SYNERGETIC EFFECTS OF MAGNETIC FIELDS

Experiments were performed anticipating that the magnetic field might enhance the effect of other stresses to which Drosophila were exposed simultaneously. Forssberg (3) observed that the mortality rate due to x-radiation increased by simultaneous exposure of Drosophila eggs to a strong magnetic field. Mortality characteristics of animal populations are remarkably constant under uniform environmental conditions and therefore a useful trait for investigation of an experimental environment. Slight detrimental conditions are expected to have a cumulative effect which will be manifested as a shortened span of life of the animal. The combined effects of magnetic fields with radiation, starvation, hyperoxia, and hypoxia on survival of Drosophila were explored.

ROENTGEN-RAYS AND MAGNETIC FIELD

Procedure

Four groups of adult Wild-type Drosophila within one day of hatch were treated in the following manner: Two groups were irradiated for ninety minutes at 41 r/min (total dose 3690r) while the other two groups were not. One irradiated and one nonirradiated group were exposed to a uniform magnetic field of 10,000 gauss while the rest served as controls under practically identical condition of temperature, humidity, illumination, and nutrition. The flies in the magnetic field stayed there for the length of their life. They were removed from the field for only a few minutes each week while being transferred to a fresh medium.

Results

Table III shows that flies kept in a strong uniform magnetic field during adult life do not undergo a significant change in their life span. Neither does an irradiation dose of 3690 r influence the maximal or mean life span. Chance may have contributed to the fact that the longest life span of all animals studied was observed in an irradiated and magnetically exposed animal. Visual inspection of the animals showed no difference in physical appearance or behavior in the four groups.

Table III

Life Span of Drosophila in a Magnetic Field, With and Without X-Irradiation

	Magnetic Field		Control	
	Irradiated	Nonirradiated	Irradiated	Nonirradiated
Number of Flies	8	9	13	13
Maximal Life Span (Days)	57	56	56	53
Mean Life Span (Days)	30	37	25	26

uniform field of 7,000 gauss and then to a control vial outside the field. The temperature in the vials was kept within 3° C of room temperature. The number of flies surviving the oxygen treatment in the magnet and in the control container was counted eighty hours after the start of the exposure in each of several experiments of this kind.

Results

The percentage of flies surviving in the magnet and in the controls varied from 22 per cent to 74 per cent in the former and from 50 per cent to 94 per cent in the latter. The differences between the vials of one group were not consistent and the apparent higher survival number of the controls cannot be construed as an adverse effect of the magnetic field.

Procedure

A similar arrangement was used in the study of the synergetic effect of hypoxia and a magnetic field. The atmosphere in the vials consisted of a humidified mixture of 5 per cent oxygen in nitrogen. The flies were kept in this gas mixture until death or approximately twenty-four hours.

Results

No difference between the number of dead flies in the magnet and that in the controls was noted at any of the various times they were observed.

DISCUSSION

The results of the present study should be considered in connection with previous investigations of Drosophila in magnetic fields. Since some of this information is not readily accessible, a short resume will be given.

Chevais and Manigault (2) placed eggs of Drosophila melanogaster in the inhomogeneous field of a permanent magnet close to the poles for the duration of about twenty-four hours at a temperature of 25° C. They measured the value of the product field strength times gradient H ($\rho H/\rho x$) and found it to be "several million C.G.S. units." The field strength was a few thousand gauss and the gradient a few hundred gauss per cm. Using the classical crossing methods of Muller, these authors observed mutations particularly of the wings as well as lethal mutations while similar mutations were not observed in the controls. No indication concerning the number of flies, the frequency of mutations, or the development stage of the embryo at exposure time is given. The effects are explained by the authors as being caused by mechanical migration of dia- and paramagnetic particles.

Table IV

Effects of Exposure of Drosophila to Magnetic Field

Biological Material	Magnetic Field: Homogeneous - H Inhomogeneous - I	Strength Gauss	Gradient Gauss/cm	Exposure Time	Effect	Investigator
Egg	H	6000		1 hour	None	Forssberg (3)
Egg	I	Several thousand	Several hundred	1 day	Mutations, partially lethal	Chevais and Manigault (2)
Life Cycle Egg to Adult	H	600-8000		days	Genetic changes	Mulay and Mulay (4)
Egg to Adult	H	20,000		days	None	Close and Beischer*
Egg to Adult	I	10,000	1300	days	None	Close and Beischer*
Adult Fly	H	10,000		56 days	None	Close and Beischer*
Adult Fly	H	120,000		1 hour	None	Beischer (1)
Adult Fly	I	40-100,000	6000	1 hour	Lethal	Beischer (1)

*Present study